



Meteorological Solutions Inc.

September 12, 2012

UTAH DEPARTMENT OF  
ENVIRONMENTAL QUALITY

OCT 30 2012

DIVISION OF AIR QUALITY

Mr. George Gooch  
ATK Launch Systems Inc.  
M/S 301  
P. O. Box 707  
Brigham City, Utah 84302-0707

Dear Mr. Gooch:

ATK retained Meteorological Solutions Inc. (MSI) to perform dispersion modeling of PM<sub>2.5</sub> emissions from small rocket motor static tests to determine if such tests conducted on historical “red burn” days would have been a contributing factor to monitored exceedances recorded at Utah Division of Air Quality (UDAQ) ambient air quality monitors. MSI obtained a list of “red burn” days and State Implementation Plan (SIP) modeling episodes from the UDAQ to determine the periods in which UDAQ was concerned with PM<sub>2.5</sub>. “Red burn” days are determined by the UDAQ Air Monitoring Center and are based on reports of air quality conditions.

MSI modeled PM<sub>2.5</sub> concentrations at the county borders located in the Salt Lake City PM<sub>2.5</sub> non-attainment area to quantify the likely highest impact from these small rocket motor tests on ambient PM<sub>2.5</sub> concentrations. To accomplish this modeling, the latest version of the EPA approved CALPUFF model (Version 5.8) was utilized. A summary of the configuration of each modeling component is presented below.

### CALMET Configuration

Meteorological data files used by CALMET predecessor included 2006-2008 Weather Research & Forecasting (WRF) model data and concurrent National Weather Service (NWS) surface meteorological data. WRF data are comprised of hourly 3D gridded observations with 34 vertical layers and 12 kilometer (km) horizontal resolution. CALMET runs were prepared for the 2006-2008 winter months (January, February, November, December) since these months define Utah’s Winter Air Quality Program wood burning season.

CALMET was configured to output one-kilometer spacing for the computational domain and contain the “red burn” days during the winter months. The domain itself measured 265 by 265 kilometers with the burn location, T-6, approximately in the center of the domain. The domain was of sufficient size to allow for plume meander and recirculation. The modeling domain, receptors and source location are presented in Figure 1. Five-day CALMET runs were made to keep the files to a manageable size (approximately 1.5 gigabytes per five-day period). The three-year WRF period resulted in 72 separate CALMET output files. CALMET 5.8 was utilized in creating the meteorological output files to be read by CALPUFF. A sample input file is presented in Attachment 1.

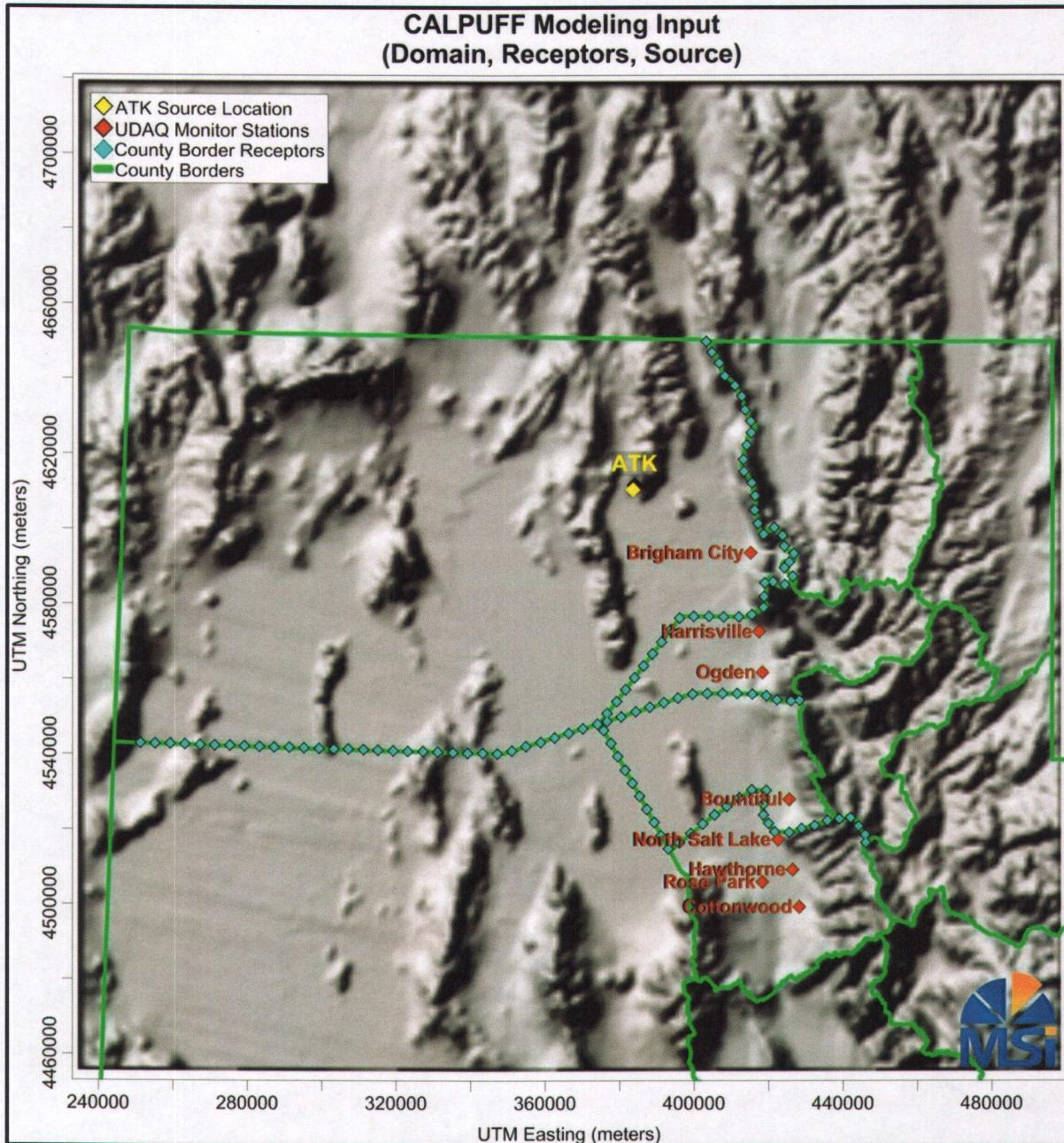


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**Figure 1 CALPUFF Modeling Domain**



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### CALPUFF Configuration

CALPUFF was configured to read the meteorological data files discussed above. The small rocket motor tests were simulated as a single hour of PM<sub>2.5</sub> emissions followed by 23 hours of zero emissions. The hourly volume source emission files were generated for the 13:00 hour. The initial plume dimension and height information for the 98,000, 45,800, 25,942, 15,590 and 7,295 pound motor burns used in CALPUFF were calculated based on meteorological data collected at the ATK M245 meteorological tower and compared to Briggs plume rise algorithms. This method was developed in conjunction with and approved by UDAQ as a representative method for modeling the rocket motor static tests. An example of the volume files is presented in Attachment 2.

PM<sub>2.5</sub> emission rates were calculated using a PM<sub>2.5</sub> emission factor developed by ATK Launch Systems for a rocket motor burn (0.019 lb./lb. of propellant). Version 5.8 of CALPUFF is only capable of an hourly emission rate (therefore the equivalent emission rate for the rocket burn was calculated in grams per second). Table 1 presents the rocket motor characteristics used to calculate volume sources and emission rates. Even though it represented an extremely conservative approach, rocket motor tests were assumed to occur on a daily basis for the entire modeling period. This method allowed CALPUFF to capture emission carryover from the previous day's burn simulation. This emission carryover is an over estimation since the static test burns do not occur on a daily basis.

**Table 1 – PM<sub>2.5</sub> Small Rocket Motor Modeling Scenarios**

Motor	Propellant Weight (pounds)				
Total Propellant Weight (lbs.)	98,000	45,800	25,942	15,590	7,295
Motor Diameter (inches)	92.0	66.0	40.0	92.0	51.6
Burn Duration (seconds)	60.0	64.0	63.3	73.5	60.0
Total PM <sub>2.5</sub> (pounds per test)	1,862	870.2	492.9	296.2	138.6



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Receptors in CALPUFF were placed at UDAQ ambient air monitor locations located within the Salt Lake City non-attainment area. The stations included in the model were Brigham City, Harrisville, Ogden, Bountiful, Hawthorne, Cottonwood, North Salt Lake, and Rose Park. In addition, discrete receptors were placed along the leading edge of the county borders that were included in the Salt Lake City non-attainment area.

### **Emission Inventory Data Development**

The UDAQ provided a workbook to MSI that contained the ATK portion of 2008 point source inventory used for the SIP modeling. The UDAQ indicated to MSI that they were utilizing the EI information contained in the workbook for static burns and those emissions were being dispersed over the entire modeling episodes. Based on the UDAQ provided workbook, the UDAQ varied the emissions by month based on the percentage of annual hours of operation by month which was contained in ATK's 2008 EI. The estimated PM<sub>2.5</sub> emission rate used by the UDAQ was significantly less than that utilized by MSI in the PM<sub>2.5</sub> CALPUFF modeling demonstration.

### **CALPUFF Results**

CALPUFF modeling was conducted utilizing 2006-2008 WRF data. Modeling was conducted during winter months (for January, February, November, and December) for 2006 through 2008. The 2007 and 2008 WRF data encompassed the first two SIP modeling episodes (January 11-20, 2007 and Feb. 14-18, 2008).

For modeling purposes, the small rocket motor burns were assumed to occur at 13:00 on a daily basis for the modeling period. This method allowed CALPUFF to capture emission carryover from the previous day's burn simulation. This emission carryover is an over estimation since the small rocket motor burns do not occur on a daily basis.



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### **98,000 Pound Rocket**

CALPUFF predicted PM<sub>2.5</sub> concentrations from the 98,000 lb. motor static burns on red burn days. The maximum CALPUFF model-predicted PM<sub>2.5</sub> concentration on any red burn day occurred on the eastern border of Box Elder County with a value of 0.0017 µg/m<sup>3</sup>. In addition, model-predicted concentrations were determined at the UDAQ ambient monitoring sites. When concentrations were compared to actual UDAQ monitored values, ATK's maximum contribution to a UDAQ monitor on a "red burn" day was 0.0003% of the measured concentration and occurred at the North Salt Lake air quality monitor. A summary of the model predicted results and the contribution to actual UDAQ monitored values is presented in Attachment 3.

### **45,800 Pound Rocket**

CALPUFF predicted PM<sub>2.5</sub> concentrations from the 45,800 lb. motor static burns on red burn days. The maximum CALPUFF model-predicted PM<sub>2.5</sub> concentration on any red burn day occurred on the eastern border of Box Elder County with a value of 0.0007 µg/m<sup>3</sup>. In addition, model-predicted concentrations were determined at the UDAQ ambient monitoring sites. When concentrations were compared to actual UDAQ monitored values, ATK's maximum contribution to a UDAQ monitor on a "red burn" day was 0.0002% of the measured concentration and occurred at the North Salt Lake air quality monitor. A summary of the model predicted results and the contribution to actual UDAQ monitored values is presented in Attachment 4.

### **25,942 Pound Rocket**

CALPUFF predicted PM<sub>2.5</sub> concentrations from the 25,942 lb. motor static burns on red burn days. The maximum CALPUFF model-predicted PM<sub>2.5</sub> concentration on any red burn day occurred on the eastern border of Box Elder County with a value of 0.0060 µg/m<sup>3</sup>. In addition, model-predicted concentrations were determined at the UDAQ ambient monitoring sites. When concentrations were compared to actual UDAQ monitored values, ATK's maximum contribution to a UDAQ monitor on a "red burn" day was 0.0060% of the measured concentration and occurred at the Brigham City air quality monitor. A summary of the model predicted results and the contribution to actual UDAQ monitored values is presented in Attachment 5.



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### **15,590 Pound Rocket**

CALPUFF predicted PM<sub>2.5</sub> concentrations from the 15,590 lb. motor static burns on red burn days. The maximum CALPUFF model-predicted PM<sub>2.5</sub> concentration on any red burn day occurred on the border of Box Elder and Weber Counties with a value of 0.0169 µg/m<sup>3</sup>. In addition, model-predicted concentrations were determined at the UDAQ ambient monitoring sites. When concentrations were compared to actual UDAQ monitored values, ATK's maximum contribution to a UDAQ monitor on a "red burn" day was 0.0197% of the measured concentration and occurred at the Ogden air quality monitor. A summary of the model predicted results and the contribution to actual UDAQ monitored values is presented in Attachment 6.

### **7,295 Pound Rocket**

CALPUFF predicted PM<sub>2.5</sub> concentrations from the 7,295 lb. motor static burns on red burn days. The maximum CALPUFF model-predicted PM<sub>2.5</sub> concentration on any red burn day occurred on the border of Box Elder and Weber Counties with a value of 0.0218 µg/m<sup>3</sup>. In addition, model-predicted concentrations were determined at the UDAQ ambient monitoring sites. When concentrations were compared to actual UDAQ monitored values, ATK's maximum contribution to a UDAQ monitor on a "red burn" day was 0.0612% of the measured concentration and occurred at the Brigham City air quality monitor. A summary of the model predicted results and the contribution to actual UDAQ monitored values is presented in Attachment 7.

PM<sub>2.5</sub> non-attainment episodes are primarily associated with cold pools when a synoptic ridge of high pressure covers the Great Basin. Cold pools consist of weak transport winds and near calm surface winds. Most of the emissions along the Wasatch Front are trapped within the cold pools and build-up while the ridge exists over the area. "Red burn" days are defined by UDAQ's Air Monitoring Center and are common during cold pool events. Results of the CALPUFF modeling show all the motor static tests would not have contributed to poor air quality on historical "red burn" days.

The buoyancy of emissions from the 98,000 lb. and 45,800 lb. motor tests lift particulate matter hundreds of meters above ground level and typically above the inversion layer. This high plume rise, in addition to a stable atmosphere, decouples fine particulate associated with the static test from the cold pool and allows for the upper atmosphere to disperse the fine particulate aloft.



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The 25,942 rocket motor tests have lower buoyancy than the 98,000 and 45,800 lb. motor tests. However, there is sufficient buoyancy in the 25,942 rocket motor tests to lift a significant portion of the plume containing the particulate matter above the stable layer. The impact from the 25,942 rocket motors on the Salt Lake City non-attainment area and UDAQ ambient monitor locations is insignificant because of the low emission rate.

The buoyancy of the 15,590 lb. rocket motor tests are also sufficient to lift a significant portion of the plume above the stable layer. The impact from the 15,590 rocket motors on the Salt Lake City non-attainment area and UDAQ ambient monitor locations is insignificant because of the low emission rate.

The 7,295 lb. rocket motor tests have relatively low buoyancy and don't rise above the stable layer to the extent of the other rocket motors. This is evident in the higher model-predicted concentrations in which the majority of the PM<sub>2.5</sub> emitted from a 7,295 lb. rocket motor burn stays below the boundary layer. However, the impact from the 7,295 lb. rocket motor on the Salt Lake City non-attainment area and UDAQ ambient monitor locations is still insignificant because of the low emission rate.

### Differences between MSI CALPUFF and UDAQ SIP Modeling Methodologies

This section describes how the UDAQ CMAQ and MSI CALPUFF modeling efforts are different. MSI recognizes that CMAQ and CALPUFF are very different models; however, both models are capable of using representative source parameters and meteorological data. The SIP modeling being conducted by UDAQ contains thousands of point and area sources from the entire Salt Lake City PM<sub>2.5</sub> non-attainment area. This modeling analysis is a detailed representation of the large rocket motor static tests conducted at ATK. Below are two major components identified for driving results from dispersion modeling efforts: source parameters/emission inventory and meteorological data and how each model represents the static tests.

- 1) The UDAQ supplied workbook contained source information (stack height, stack diameter, stack temperature, and exit velocity) which was presumably used in the CMAQ modeling. This information assumed a 10 meter stack height, a one meter stack diameter, an exit temperature of 72°F, an exit flow of 15.28 m/s.

The small rocket motor static tests burn over 98,000, 45,800, 25,942, 15,590, and 7,295 lbs. of propellant, respectively in approximately a one-minute period. The buoyancy of the rocket exhaust drives the plume hundreds of meters above ground level.



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The source parameters incorporated in the CALPUFF modeling used ATK's M245 meteorological tower data and Briggs plume rise algorithms to calculate volume source dimensions.

- 2) Meteorological data in the UDAQ CMAQ modeling consisted of various combinations of MM5, WRF and surface observation data processed for three (3) episodes determined to have large air quality data bases and representative conditions leading to elevated PM<sub>2.5</sub> (January 11-20, 2007, February 14-18, 2008, and December 8, 2009 - January 22, 2010). MSI's CALPUFF modeling focused on winter months (January, February, November, and December) for 2006 through 2008. WRF data and surface observation data were utilized for the months modeled. Both meteorological data sets will be very similar during the overlapping periods modeled since WRF data were used in both models.

### Summary

MSI conducted modeling to determine the potential impact of the ATK's small rocket motor static tests on UDAQ monitor locations and county borders of counties located in the Salt Lake City PM<sub>2.5</sub> non-attainment area. Results of the modeling show that 98,000, 45,800, 25,942, 15,590, and 7,295 lb. rocket motor tests would have negligible impact ( $0.02 \mu\text{g}/\text{m}^3$ ) on county borders or UDAQ ambient air quality sites during historical "red burn" days. The buoyancy of emissions from the 98,000 and 45,800 lb. motor tests lift particulate matter hundreds of meters above ground level and above the cold pool. This high plume rise, in addition to a stable atmosphere, decouples fine particulate associated with the static test from the cold pool and allows for the upper atmosphere to disperse the fine particulate aloft. The 25,942 and 15,590 lb. rocket motor tests have lower buoyancy than the 98,000 and 45,800 lb. rocket motor but the buoyancy is sufficient to lift a significant portion of the plume containing the particulate matter above the stable layer. The buoyancy of emissions from the 7,295 lb. rocket motor test typically does not lift the particulate above the boundary layer. The CALPUFF analysis shows that the impact from the small rocket motor tests is insignificant.

If you have any questions, feel free to contact me.

Sincerely,

A handwritten signature in black ink, appearing to read "George Wilkerson".

George Wilkerson  
President

SA:\lec\\BIG\_MAX\share\msi\_server\Msi\Projects\12-66 ATK PM2.5 Modeling\Smaller Rocket Modeling Report\Small Rocket Motor Summary-Revised.docx



**Attachment 1**  
**Sample CALMET Input File**

## 0101-0105.INP

CALMET Run for ATK Launch Systems SIP  
 Grid Resolution: 1 KM  
 CALMET Control INP File for 1/1-1/15 2006  
 ----- Run title (3 lines) -----

## CALMET MODEL CONTROL FILE

-----  
INPUT GROUP: 0 -- Input and Output File Names

## Subgroup (a)

Default Name	Type	File Name
GEO.DAT	input	! GEODAT=C:\ATKPM\CALMET\ATKGEO.DAT !
SURF.DAT	input	! SRFDAT=C:\ATKPM\calmet\smerge\SURF2006.DAT !
CLOUD.DAT	input	* CLDDAT= * !
PRECIP.DAT	input	! PRCDAT=C:\ATKPM\CALMET\PMERGE\PRECIP2006.DAT !
WT.DAT	input	* WTDAT= * !
CALMET.LST	output	! METLST=C:\ATKPM\CALMET\2006\0101-0105.LST !
CALMET.DAT	output	! METDAT=C:\ATKPM\CALMET\2006\0101-0105.MET !
PACOUT.DAT	output	* PACDAT= * !

All file names will be converted to lower case if LCFILES = T  
 Otherwise, if LCFILES = F, file names will be converted to UPPER CASE  
 T = lower case ! LCFILES = T !  
 F = UPPER CASE

## NUMBER OF UPPER AIR &amp; OVERWATER STATIONS:

Number of upper air stations (NUSTA) No default ! NUSTA = 3 !  
 Number of overwater met stations  
 (NOWSTA) No default ! NOWSTA = 0 !

## NUMBER OF PROGNOSTIC and IGF-CALMET FILES:

Number of MM4/MM5/3D.DAT files  
 (NM3D) No default ! NM3D = 2 !  
 Number of IGF-CALMET.DAT files  
 (NIGF) No default ! NIGF = 0 !  
 !END!

-----  
Subgroup (b)

## Upper air files (one per station)

Default Name	Type	File Name
UP1.DAT	input	1 ! UPDAT=C:\ATKPM\CALMET\READ62\UP_SLC_06.DAT! !END!
UP2.DAT	input	2 ! UPDAT=C:\ATKPM\CALMET\READ62\UP_BOI_06.DAT! !END!
UP3.DAT	input	3 ! UPDAT=C:\ATKPM\CALMET\READ62\UP_RVT_06.DAT! !END!

-----  
Subgroup (c)

## Overwater station files (one per station)

Default Name	Type	File Name
SEA1.DAT	input	1 * SEADAT=SEA_449.DAT * *END*

-----  
Subgroup (d)

## MM4/MM5/3D.DAT files (consecutive or overlapping)

Default Name	Type	File Name
MM51.DAT	input	1 ! M3DDAT=i:\ord_nlcd\calwrf_v14\calwrf.2006-01-01.M3D! !END!
MM52.DAT	input	2 ! M3DDAT=i:\ord_nlcd\calwrf_v14\calwrf.2006-01-06.M3D! !END!

-----  
Subgroup (e)

## IGF-CALMET.DAT files (consecutive or overlapping)

## 0101-0105.INP

---

Default Name	Type	File Name
IGFn.DAT	input	1 * IGFDAT=CALMET0.DAT * *END*

---

Subgroup (f)

Other file names

---

Default Name	Type	File Name
DIAG.DAT	input	* DIADAT= *
PROG.DAT	input	* PRGDAT= *
TEST.PRT	output	* TSTPRT= *
TEST.OUT	output	* TSTOUT= *
TEST.KIN	output	* TSTKIN= *
TEST.FRD	output	* TSTFRD= *
TEST.SLP	output	* TSTS LP= *
DCST.GRD	output	* DCSTGD= *

---

NOTES: (1) File/path names can be up to 70 characters in length  
 (2) Subgroups (a) and (f) must have ONE 'END' (surrounded by delimiters) at the end of the group  
 (3) Subgroups (b) through (e) are included ONLY if the corresponding number of files (NUSTA, NOWSTA, NM3D, NIGF) is not 0, and each must have an 'END' (surround by delimiters) at the end of EACH LINE

!END!

---

INPUT GROUP: 1 -- General run control parameters

---

Starting date: Year (IBYR) -- No default ! IBYR= 2006 !  
 Month (IBMO) -- No default ! IBMO= 1 !  
 Day (IBDY) -- No default ! IBDY= 1 !  
 Hour (IBHR) -- No default ! IBHR= 1 !

Note: IBHR is the time at the END of the first hour of the simulation  
 (IBHR=1, the first hour of a day, runs from 00:00 to 01:00)

Base time zone (IBTZ) -- No default ! IBTZ= 07 !  
 PST = 08, MST = 07  
 CST = 06, EST = 05

Length of run (hours) (IRLG) -- No default ! IRLG= 120 !

Run type (IRTYPE) -- Default: 1 ! IRTYPE= 1 !

0 = Computes wind fields only  
 1 = Computes wind fields and micrometeorological variables  
 (u\*, w\*, L, zi, etc.)  
 (IRTYPE must be 1 to run CALPUFF or CALGRID)

Compute special data fields required  
 by CALGRID (i.e., 3-D fields of W wind  
 components and temperature)  
 in addition to regular fields ? (LCALGRD)  
 (LCALGRD must be T to run CALGRID)

Flag to stop run after  
 SETUP phase (ITEST) Default: 2 ! ITEST= 2 !  
 (Used to allow checking  
 of the model inputs, files, etc.)  
 ITEST = 1 - STOPS program after SETUP phase  
 ITEST = 2 - Continues with execution of  
 COMPUTATIONAL phase after SETUP

Test options specified to see if  
 they conform to regulatory  
 values? (MREG) No Default ! MREG = 1 !

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0 = NO checks are made  
1 = Technical options must conform to USEPA guidance  
IMIXH -1 Maul-Carson convective mixing height  
over land; OCD mixing height overwater  
ICOARE 0 OCD deltaT method for overwater fluxes  
THRESHL 0.0 Threshold buoyancy flux over land needed  
to sustain convective mixing height growth

!END!

-----  
INPUT GROUP: 2 -- Map Projection and Grid control parameters  
-----

Projection for all (X,Y):  
-----

Map projection  
(PMAP) Default: UTM ! PMAP = UTM !

UTM : Universal Transverse Mercator  
TTM : Tangential Transverse Mercator  
LCC : Lambert Conformal Conic  
PS : Polar Stereographic  
EM : Equatorial Mercator  
LAZA : Lambert Azimuthal Equal Area

False Easting and Northing (km) at the projection origin  
(Used only if PMAP= TTM, LCC, or LAZA)  
(FEAST) Default=0.0 ! FEAST = 0.000 !  
(FNORTH) Default=0.0 ! FNORTH = 0.000 !

UTM zone (1 to 60)  
(Used only if PMAP=UTM)  
(IUTMZN) No Default ! IUTMZN = 12 !

Hemisphere for UTM projection?  
(Used only if PMAP=UTM)  
(UTMHEM) Default: N ! UTMHEM = N !  
N : Northern hemisphere projection  
S : Southern hemisphere projection

Latitude and Longitude (decimal degrees) of projection origin  
(Used only if PMAP= TTM, LCC, PS, EM, or LAZA)  
(RLATO) No Default ! RLATO = 41.5N !  
(RLONO) No Default ! RLONO = 112W !

TTM : RLONO identifies central (true N/S) meridian of projection  
RLATO selected for convenience  
LCC : RLONO identifies central (true N/S) meridian of projection  
RLATO selected for convenience  
PS : RLONO identifies central (grid N/S) meridian of projection  
RLATO selected for convenience  
EM : RLONO identifies central meridian of projection  
RLATO is REPLACED by 0.0N (Equator)  
LAZA: RLONO identifies longitude of tangent-point of mapping plane  
RLATO identifies latitude of tangent-point of mapping plane

Matching parallel(s) of latitude (decimal degrees) for projection  
(Used only if PMAP= LCC or PS)  
(XLAT1) No Default ! XLAT1 = 40N !  
(XLAT2) No Default ! XLAT2 = 44N !

LCC : Projection cone slices through Earth's surface at XLAT1 and XLAT2  
PS : Projection plane slices through Earth at XLAT1  
(XLAT2 is not used)

-----  
Note: Latitudes and longitudes should be positive, and include a  
letter N,S,E, or W indicating north or south latitude, and  
east or west longitude. For example,  
35.9 N Latitude = 35.9N  
118.7 E Longitude = 118.7E

Datum-region  
-----

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The Datum-Region for the coordinates is identified by a character string. Many mapping products currently available use the model of the Earth known as the World Geodetic System 1984 (WGS-84). Other local models may be in use, and their selection in CALMET will make its output consistent with local mapping products. The list of Datum-Regions with official transformation parameters is provided by the National Imagery and Mapping Agency (NIMA).

NIMA Datum - Regions(Examples)

---

WGS-84	WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
NAS-C	NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
NAR-C	NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
NWS-84	NWS 6370KM Radius, Sphere
ESR-S	ESRI REFERENCE 6371KM Radius, Sphere

---

Datum-region for output coordinates  
(DATUM) Default: WGS-84 ! DATUM = WGS-84 !

Horizontal grid definition:

---

Rectangular grid defined for projection PMAP,  
with X the Easting and Y the Northing coordinate

No. X grid cells (NX)	No default	! NX = 265 !
No. Y grid cells (NY)	No default	! NY = 265 !
Grid spacing (DGRIDKM)	No default	! DGRIDKM = 1. !
	Units: km	

---

Reference grid coordinate of  
SOUTHWEST corner of grid cell (1,1)

X coordinate (XORIGKM)	No default	! XORIGKM = 234.000 !
Y coordinate (YORIGKM)	No default	! YORIGKM = 4455.000 !
	Units: km	

Vertical grid definition:

---

No. of vertical layers (NZ)	No default	! NZ = 10 !
cell face heights in arbitrary vertical grid (ZFACE(NZ+1))	No defaults	
	Units: m	
! ZFACE = 0.,20.,50.,100.,250.,500.,1000.,1500.,2000.,3500.,4000. !		

!END!

---

INPUT GROUP: 3 -- Output Options

---

DISK OUTPUT OPTION

Save met. fields in an unformatted  
output file ? (LSAVE) Default: T ! LSAVE = T !  
(F = Do not save, T = Save)

Type of unformatted output file:  
(IFORMO) Default: 1 ! IFORMO = 1 !

1 = CALPUFF/CALGRID type file (CALMET.DAT)  
2 = MESOPUFF-II type file (PACOUT.DAT)

LINE PRINTER OUTPUT OPTIONS:

Print met. fields ? (LPRINT) Default: F ! LPRINT = F !  
(F = Do not print, T = Print)  
(NOTE: parameters below control which  
met. variables are printed)

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Print interval  
(IPRINF) in hours Default: 1 ! IPRINF = 1 !  
(Meteorological fields are printed  
every 1 hours)

Specify which layers of u, v wind component  
to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered  
(0=Do not print, 1=Print)  
(used only if LPRINT=T) Defaults: NZ\*0  
! IUVOUT = 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 !

Specify which levels of the w wind component to print  
(NOTE: w defined at TOP cell face -- 10 values)  
(IWOUT(NZ)) -- NOTE: NZ values must be entered  
(0=Do not print, 1=Print)  
(used only if LPRINT=T & LCALGRD=T)

-----  
! IWOUT = 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 !

Specify which levels of the 3-D temperature field to print  
(ITOUT(NZ)) -- NOTE: NZ values must be entered  
(0=Do not print, 1=Print)  
(used only if LPRINT=T & LCALGRD=T)

-----  
! ITOUT = 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 !

Specify which meteorological fields  
to print  
(used only if LPRINT=T) Defaults: 0 (all variables)

Variable Print ?  
(0 = do not print,  
1 = print)  
-----  
! STABILITY = 0 ! - PGT stability class  
! USTAR = 0 ! - Friction velocity  
! MONIN = 0 ! - Monin-Obukhov length  
! MIXHT = 0 ! - Mixing height  
! WSTAR = 0 ! - Convective velocity scale  
! PRECIP = 0 ! - Precipitation rate  
! SENSHEAT = 0 ! - Sensible heat flux  
! CONVZI = 0 ! - Convective mixing ht.

Testing and debug print options for micrometeorological module

Print input meteorological data and  
internal variables (LDB) Default: F ! LDB = F !  
(F = Do not print, T = print)  
(NOTE: this option produces large amounts of output)

First time step for which debug data  
are printed (NN1) Default: 1 ! NN1 = 1 !

Last time step for which debug data  
are printed (NN2) Default: 1 ! NN2 = 1 !

Print distance to land  
internal variables (LDBCST) Default: F ! LDBCST = F !  
(F = Do not print, T = print)  
(Output in .GRD file DCST.GRD, defined in input group 0)

Testing and debug print options for wind field module  
(all of the following print options control output to  
wind field module's output files: TEST.PRT, TEST.OUT,  
TEST.KIN, TEST.FRD, and TEST.SLP)

Control variable for writing the test/debug  
wind fields to disk files (IOUTD)

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```

(0=Do not write, 1=write)      Default: 0      ! IOUTD = 0 !
Number of levels, starting at the surface,
to print (NZPRN2)            Default: 1      ! NZPRN2 = 0 !
Print the INTERPOLATED wind components ?
(IPR0) (0=no, 1=yes)          Default: 0      ! IPR0 = 0 !
Print the TERRAIN ADJUSTED surface wind
components ?
(IPR1) (0=no, 1=yes)          Default: 0      ! IPR1 = 0 !
Print the SMOOTHED wind components and
the INITIAL DIVERGENCE fields ?
(IPR2) (0=no, 1=yes)          Default: 0      ! IPR2 = 0 !
Print the FINAL wind speed and direction
fields ?
(IPR3) (0=no, 1=yes)          Default: 0      ! IPR3 = 0 !
Print the FINAL DIVERGENCE fields ?
(IPR4) (0=no, 1=yes)          Default: 0      ! IPR4 = 0 !
Print the winds after KINEMATIC effects
are added ?
(IPR5) (0=no, 1=yes)          Default: 0      ! IPR5 = 0 !
Print the winds after the FROUDE NUMBER
adjustment is made ?
(IPR6) (0=no, 1=yes)          Default: 0      ! IPR6 = 0 !
Print the winds after SLOPE FLOWS
are added ?
(IPR7) (0=no, 1=yes)          Default: 0      ! IPR7 = 0 !
Print the FINAL wind field components ?
(IPR8) (0=no, 1=yes)          Default: 0      ! IPR8 = 0 !

```

!END!

---

#### INPUT GROUP: 4 -- Meteorological data options

---

```

NO OBSERVATION MODE          (NOOBS) Default: 0      ! NOOBS = 0 !
  0 = Use surface, overwater, and upper air stations
  1 = Use surface and overwater stations (no upper air observations)
    Use MM4/MM5/3D.DAT for upper air data
  2 = No surface, overwater, or upper air observations
    Use MM4/MM5/3D.DAT for surface, overwater, and upper air data

```

#### NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

```

Number of surface stations   (NSSTA) No default      ! NSSTA = 9 !
Number of precipitation stations
(NPSTA=-1: flag for use of MM5/3D.DAT precip data)
(NPSTA) No default          ! NPSTA = 9 !

```

#### CLOUD DATA OPTIONS

```

Gridded cloud fields:        (ICLOUD) Default: 0      ! ICLOUD = 0 !
  ICLOUD = 0 - Gridded clouds not used
  ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
  ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
  ICLOUD = 3 - Gridded cloud cover from Prognostic Rel. Humidity
                at 850mb (Teixeira)

```

#### FILE FORMATS

```

Surface meteorological data file format
(IFORMS) Default: 2      ! IFORMS = 2 !
(1 = unformatted (e.g., SMERGE output))
(2 = formatted (free-formatted user input))

```

```

Precipitation data file format
(IFORMP) Default: 2      ! IFORMP = 2 !

```

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(1 = unformatted (e.g., PMERGE output))  
 (2 = formatted (free-formatted user input))

Cloud data file format  
 (IFORMC) Default: 2 ! IFORMC = 2 !  
 (1 = unformatted - CALMET unformatted output)  
 (2 = formatted - free-formatted CALMET output or user input)

!END!

---

INPUT GROUP: 5 -- Wind Field Options and Parameters

---

WIND FIELD MODEL OPTIONS

Model selection variable (IWFCOD)	Default: 1	! IWFCOD = 1 !
0 = Objective analysis only		
1 = Diagnostic wind module		
Compute Froude number adjustment effects ? (IFRADJ)	Default: 1	! IFRADJ = 1 !
(0 = NO, 1 = YES)		
Compute kinematic effects ? (IKINE)	Default: 0	! IKINE = 0 !
(0 = NO, 1 = YES)		
Use O'Brien procedure for adjustment of the vertical velocity ? (IOBR)	Default: 0	! IOBR = 0 !
(0 = NO, 1 = YES)		
Compute slope flow effects ? (ISLOPE)	Default: 1	! ISLOPE = 1 !
(0 = NO, 1 = YES)		
Extrapolate surface wind observations to upper layers ? (IEXTNP)	Default: -4	! IEXTNP = -4 !
(1 = no extrapolation is done, 2 = power law extrapolation used, 3 = user input multiplicative factors for layers 2 - NZ used (see FEXTRP array) 4 = similarity theory used -1, -2, -3, -4 = same as above except layer 1 data at upper air stations are ignored		
Extrapolate surface winds even if calm? (ICALM)	Default: 0	! ICALM = 0 !
(0 = NO, 1 = YES)		
Layer-dependent biases modifying the weights of surface and upper air stations (BIAS(NZ))		
-1<=BIAS<=1		
Negative BIAS reduces the weight of upper air stations (e.g. BIAS=-0.1 reduces the weight of upper air stations by 10%; BIAS= -1, reduces their weight by 100 %)		
Positive BIAS reduces the weight of surface stations (e.g. BIAS= 0.2 reduces the weight of surface stations by 20%; BIAS=1 reduces their weight by 100%)		
Zero BIAS leaves weights unchanged (1/R**2 interpolation)		
Default: NZ*0		
	! BIAS = 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 !	
Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed (RMIN2: Set to -1 for IEXTNP = 4 or other situations where all surface stations should be extrapolated)		
	Default: 4.                                                  ! RMIN2 = -1.0 !	
Use gridded prognostic wind field model output fields as input to the diagnostic wind field model (IPROG)	Default: 0	! IPROG = 14 !
(0 = No, [IWFCOD = 0 or 1]		
1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]		
2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]		
3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]		
4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD = 1]		
5 = Yes, use winds from MM4.DAT file as observations [IWFCOD = 1]		

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13 = Yes, use winds from MM5/3D.DAT file as Step 1 field [IWFCOD = 0]  
 14 = Yes, use winds from MM5/3D.DAT file as initial guess field [IWFCOD = 1]  
 15 = Yes, use winds from MM5/3D.DAT file as observations [IWFCOD = 1]

Timestep (hours) of the prognostic  
model input data (ISTEPPG) Default: 1 ! ISTEPPG = 1 !

Use coarse CALMET fields as initial guess fields (IGFMET)  
(overwrites IGF based on prognostic wind fields if any)  
Default: 0 ! IGFMET = 0 !

## RADIUS OF INFLUENCE PARAMETERS

Use varying radius of influence Default: F ! LVARY = F!  
(if no stations are found within RMAX1,RMAX2,  
or RMAX3, then the closest station will be used)

Maximum radius of influence over land  
in the surface layer (RMAX1) No default ! RMAX1 = 100. !  
Units: km

Maximum radius of influence over land  
aloft (RMAX2) No default ! RMAX2 = 200. !  
Units: km

Maximum radius of influence over water  
(RMAX3) No default ! RMAX3 = 200. !  
Units: km

## OTHER WIND FIELD INPUT PARAMETERS

Minimum radius of influence used in  
the wind field interpolation (RMIN) Default: 0.1 ! RMIN = 0.1 !  
Units: km

Radius of influence of terrain  
features (TERRAD) No default ! TERRAD = 15. !  
Units: km

Relative weighting of the first  
guess field and observations in the  
SURFACE layer (R1)  
(R1 is the distance from an  
observational station at which the  
observation and first guess field are  
equally weighted) No default ! R1 = 50. !  
Units: km

Relative weighting of the first  
guess field and observations in the  
Layers ALOFT (R2)  
(R2 is applied in the upper layers  
in the same manner as R1 is used in  
the surface layer). No default ! R2 = 100. !  
Units: km

Relative weighting parameter of the  
prognostic wind field data (RPROG)  
(Used only if IPROG = 1) No default ! RPROG = 0. !  
-----

Maximum acceptable divergence in the  
divergence minimization procedure  
(DIVLIM) Default: 5.E-6 ! DIVLIM= 5.0E-06 !

Maximum number of iterations in the  
divergence min. procedure (NITER) Default: 50 ! NITER = 50 !

Number of passes in the smoothing  
procedure (NSMTH(NZ))

NOTE: NZ values must be entered

Default: 2,(mxnz-1)\*4 ! NSMTH =  
2 , 4 , 4 , 4 , 4 , 4 , 4 , 4 , 4 !

Maximum number of stations used in  
each layer for the interpolation of  
data to a grid point (NINTR2(NZ))

NOTE: NZ values must be entered Default: 99. ! NINTR2 =  
99 , 99 , 99 , 99 , 99 , 99 , 99 , 99 !

Critical Froude number (CRITFN) Default: 1.0 ! CRITFN = 1. !

Empirical factor controlling the

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influence of kinematic effects  
(ALPHA)

Default: 0.1 ! ALPHA = 0.1 !

Multiplicative scaling factor for  
extrapolation of surface observations  
to upper layers (FEXTR2(NZ)) Default: NZ\*0.0  
! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0., 0. !  
(Used only if IEXTRP = 3 or -3)

#### BARRIER INFORMATION

Number of barriers to interpolation  
of the wind fields (NBAR) Default: 0 ! NBAR = 0 !

Level (1 to NZ) up to which barriers  
apply (KBAR) Default: NZ ! KBAR = 10 !

#### THE FOLLOWING 4 VARIABLES ARE INCLUDED

ONLY IF NBAR > 0

NOTE: NBAR values must be entered  
for each variable No defaults  
Units: km

X coordinate of BEGINNING  
of each barrier (XBBAR(NBAR)) ! XBBAR = 0. !

Y coordinate of BEGINNING  
of each barrier (YBBAR(NBAR)) ! YBBAR = 0. !

X coordinate of ENDING  
of each barrier (XEVAR(NBAR)) ! XEVAR = 0. !

Y coordinate of ENDING  
of each barrier (YEVAR(NBAR)) ! YEVAR = 0. !

#### DIAGNOSTIC MODULE DATA INPUT OPTIONS

Surface temperature (IDIOPT1) Default: 0 ! IDIOPT1 = 0 !

0 = Compute internally from  
hourly surface observations or prognostic fields  
1 = Read preprocessed values from  
a data file (DIAG.DAT)

Surface met. station to use for  
the surface temperature (ISURFT) No default ! ISURFT = 5 !  
(Must be a value from 1 to NSSTA)  
(Used only if IDIOPT1 = 0)

Temperature lapse rate used in the Default: 0 ! IDIOPT2 = 0 !  
computation of terrain-induced  
circulations (IDIOPT2)

0 = Compute internally from (at least) twice-daily  
upper air observations or prognostic fields  
1 = Read hourly preprocessed values  
from a data file (DIAG.DAT)

Upper air station to use for  
the domain-scale lapse rate (IUPPT) No default ! IUPPT = 1 !  
(Must be a value from 1 to NUSTA)  
(Used only if IDIOPT2 = 0)

Depth through which the domain-scale  
lapse rate is computed (ZUPT) Default: 200. ! ZUPT = 200. !  
(Used only if IDIOPT2 = 0) Units: meters

Initial Guess Field Winds  
(IDIOPT3) Default: 0 ! IDIOPT3 = 0 !

0 = Compute internally from  
observations or prognostic wind fields  
1 = Read hourly preprocessed domain-average wind values  
from a data file (DIAG.DAT)

Upper air station to use for  
the initial guess winds (IUPWND) Default: -1 ! IUPWND = -1 !  
(Must be a value from -1 to NUSTA, with  
-1 indicating 3-D initial guess fields,  
and IUPWND>1 domain-scaled (i.e. constant) IGF)

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(Used only if IDIOPT3 = 0)

Bottom and top of layer through  
which the domain-scale winds  
are computed  
(ZUPWND(1), ZUPWND(2))      Defaults: 1., 1000. ! ZUPWND= 1., 1000. !  
(Used only if IDIOPT3 = 0, NOOBS>0 and IUPWND>0)      Units: meters

Observed surface wind components  
for wind field module (IDIOPT4) Default: 0      ! IDIOPT4 = 0 !  
0 = Read WS, WD from a surface  
data file (SURF.DAT)  
1 = Read hourly preprocessed U, V from  
a data file (DIAG.DAT)

Observed upper air wind components  
for wind field module (IDIOPT5) Default: 0      ! IDIOPT5 = 0 !  
0 = Read WS, WD from an upper  
air data file (UP1.DAT, UP2.DAT, etc.)  
1 = Read hourly preprocessed U, V from  
a data file (DIAG.DAT)

## LAKE BREEZE INFORMATION

Use Lake Breeze Module (LLBREEZE)      Default: F      ! LLBREEZE = F !

Number of lake breeze regions (NBOX)      ! NBOX = 0 !

X Grid line 1 defining the region of interest      ! XG1 = 0. !

X Grid line 2 defining the region of interest      ! XG2 = 0. !

Y Grid line 1 defining the region of interest      ! YG1 = 0. !

Y Grid line 2 defining the region of interest      ! YG2 = 0. !

X Point defining the coastline (straight line)  
(XBCST) (KM)      Default: none ! XBCST = 0. !

Y Point defining the coastline (straight line)  
(YBCST) (KM)      Default: none ! YBCST = 0. !

X Point defining the coastline (straight line)  
(XECST) (KM)      Default: none ! XECST = 0. !

Y Point defining the coastline (straight line)  
(YECST) (KM)      Default: none ! YECST = 0. !

Number of stations in the region      Default: none ! NLB = 0 !  
(Surface stations + upper air stations)

Station ID's in the region (METBXID(NLB))  
(Surface stations first, then upper air stations)  
! METBXID = 0 !

!END!

## INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters

## EMPIRICAL MIXING HEIGHT CONSTANTS

Neutral, mechanical equation (CONSTB)	Default: 1.41      ! CONSTB = 1.41 !
Convective mixing ht. equation (CONSTE)	Default: 0.15      ! CONSTE = 0.15 !
Stable mixing ht. equation (CONSTN)	Default: 2400.      ! CONSTN = 2400. !
Overwater mixing ht. equation (CONSTW)	Default: 0.16      ! CONSTW = 0.16 !
Absolute value of Coriolis	

parameter (FCORIOL) 0101-0105.INP  
 Default: 1.E-4 ! FCORIOL = 1.0E-04!  
 Units: (1/s)

#### Spatial Averaging of Mixing Heights

Conduct spatial averaging (IAVEZI) (0=no, 1=yes)	Default: 1	! IAVEZI = 1 !
Max. search radius in averaging process (MNMDAV)	Default: 1	! MNMDAV = 1 !
Units: Grid cells		
Half-angle of upwind looking cone for averaging (HAFANG)	Default: 30.	! HAFANG = 30. !
Units: deg.		
Layer of winds used in upwind averaging (ILEVZI) <small>(must be between 1 and NZ)</small>	Default: 1	! ILEVZI = 1 !

#### Convective Mixing Height Options:

Method to compute the convective mixing height(IMIXH)	Default: 1	! IMIXH = -1 !
1: Maul-Carson for land and water cells		
-1: Maul-Carson for land cells only - OCD mixing height overwater		
2: Batchvarova and Gryning for land and water cells		
-2: Batchvarova and Gryning for land cells only OCD mixing height overwater		

Threshold buoyancy flux required to sustain convective mixing height growth overland (THRESHL)	Default: 0.05	! THRESHL = 0. !
(Expressed as a heat flux per meter of boundary layer)	units: W/m <sup>3</sup>	

Threshold buoyancy flux required to sustain convective mixing height growth overwater (THRESHW)	Default: 0.05	! THRESHW = 0.05 !
(Expressed as a heat flux per meter of boundary layer)	units: W/m <sup>3</sup>	

Option for overwater lapse rates used in convective mixing height growth (ITWPROG)	Default: 0	! ITWPROG = 0 !
0 : use SEA.DAT lapse rates and deltaT (or assume neutral conditions if missing)		
1 : use prognostic lapse rates (only if IPROG>2) and SEA.DAT deltaT (or neutral if missing)		
2 : use prognostic lapse rates and prognostic delta T (only if iprog>12 and 3D.DAT version# 2.0 or higher)		

Land Use category ocean in 3D.DAT datasets (ILUOC3D)	Default: 16	! ILUOC3D = 16 !
Note: if 3D.DAT from MM5 version 3.0, iluoc3d = 16 <small>if MM4.DAT, typically iluoc3d = 7</small>		

#### Other Mixing Height Variables

Minimum potential temperature lapse rate in the stable layer above the current convective mixing ht. (DPTMIN)	Default: 0.001	! DPTMIN = 0.001 !
Depth of layer above current conv. mixing height through which lapse rate is computed (DZZI)	Default: 200.	! DZZI = 200. !
Units: meters		
Minimum overland mixing height (ZIMIN)	Default: 50.	! ZIMIN = 50. !
Maximum overland mixing height (ZIMAX)	Default: 3000.	! ZIMAX = 3000. !
Units: meters		
Minimum overwater mixing height (ZIMINW) -- (Not used if observed overwater mixing hts. are used)	Default: 50.	! ZIMINW = 50. !
Units: meters		
Maximum overwater mixing height (ZIMAXW) -- (Not used if observed	Default: 3000.	! ZIMAXW = 3000. !
Units: meters		

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overwater mixing hts. are used)

OVERWATER SURFACE FLUXES METHOD and PARAMETERS  
 (ICOARE) Default: 10 ! ICOARE = 0  
 0: original deltaT method (OCD)  
 10: COARE with no wave parameterization (jwave=0, Charnock)  
 11: COARE with wave option jwave=1 (Oost et al.)  
 and default wave properties  
 -11: COARE with wave option jwave=1 (Oost et al.)  
 and observed wave properties (must be in SEA.DAT files)  
 12: COARE with wave option 2 (Taylor and Yelland)  
 and default wave properties  
 -12: COARE with wave option 2 (Taylor and Yelland)  
 and observed wave properties (must be in SEA.DAT files)

Coastal/Shallow water length scale (DSHELF)  
 (for modified z0 in shallow water)  
 ( COARE fluxes only) Default : 0. ! DSHELF = 0. !  
 units: km

COARE warm layer computation (IWARM) ! IWARM = 0 !  
 1: on - 0: off (must be off if SST measured with  
 IR radiometer) Default: 0

COARE cool skin layer computation (ICOOL) ! ICOOL = 0 !  
 1: on - 0: off (must be off if SST measured with  
 IR radiometer) Default: 0

TEMPERATURE PARAMETERS

3D temperature from observations or  
 from prognostic data? (ITPROG) Default:0 ! ITPROG = 0 !  
 0 = Use Surface and upper air stations  
 (only if NOOBS = 0)  
 1 = Use Surface stations (no upper air observations)  
 Use MM5/3D.DAT for upper air data  
 (only if NOOBS = 0,1)  
 2 = No surface or upper air observations  
 Use MM5/3D.DAT for surface and upper air data  
 (only if NOOBS = 0,1,2)

Interpolation type  
 (1 = 1/R ; 2 = 1/R\*\*2) Default:1 ! IRAD = 1 !  
 Radius of influence for temperature  
 interpolation (TRADKM) Default: 500. ! TRADKM = 500.  
 Units: km

Maximum Number of stations to include  
 in temperature interpolation (NUMTS) Default: 5 ! NUMTS = 5 !

Conduct spatial averaging of temp-  
 eratures (IAVET) (0=no, 1=yes)  
 (will use mixing ht MNMDAV,HAFANG  
 so make sure they are correct) Default: 1 ! IAVET = 1 !

Default temperature gradient  
 below the mixing height over  
 water (TGDEFB) Default: -0.0098 ! TGDEFB = -0.0098  
 Units: K/m

Default temperature gradient  
 above the mixing height over  
 water (TGDEFA) Default: -0.0045 ! TGDEFA = -0.0045  
 Units: K/m

Beginning (JWAT1) and ending (JWAT2)  
 Land use categories for temperature  
 interpolation over water -- Make  
 bigger than largest land use to disable ! JWAT1 = 55 !  
 ! JWAT2 = 55 !

## PRECIP INTERPOLATION PARAMETERS

Method of interpolation (NFLAGP)      Default: 2      ! NFLAGP = 2 !  
 (1=R,2=1/R\*\*2,3=EXP/R\*\*2)  
 Radius of Influence (SIGMAP)      Default: 100.0      ! SIGMAP = 100. !  
 (0.0 => use half dist. btwn  
 nearest stns w & w/out

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```

precip when NFLAGP = 3)
Minimum Precip. Rate Cutoff (CUTP)      Default: 0.01      ! CUTP = 0.01 !
(values < CUTP = 0.0 mm/hr)          Units: mm/hr
!END!

```

---

INPUT GROUP: 7 -- Surface meteorological station parameters

---

SURFACE STATION VARIABLES  
(One record per station -- 9 records in all)

	1	2	Name	ID	X coord. (km)	Y coord. (km)	Time zone	Anem. Ht.(m)
!	SS1	='BYI'	24133	272.384	4713.792	7	10	!
!	SS2	='EVW'	4111	497.404	4569.064	7	10	!
!	SS3	='HIF'	24101	418.321	4552.868	7	10	!
!	SS4	='LGU'	94128	429.366	4626.070	7	10	!
!	SS5	='OGD'	24126	414.755	4561.458	7	10	!
!	SS6	='PIH'	24156	372.129	4752.752	7	10	!
!	SS7	='PVU'	24174	438.993	4452.311	7	10	!
!	SS8	='SLC'	24127	418.436	4515.155	7	10	!
!	SS9	='TWF'	94178	213.696	4709.324	7	10	!

---

1  
Four character string for station name  
(MUST START IN COLUMN 9)

2  
Six digit integer for station ID

!END!

---

INPUT GROUP: 8 -- Upper air meteorological station parameters

---

UPPER AIR STATION VARIABLES  
(One record per station -- 3 records in all)

	1	2	Name	ID	X coord. (km)	Y coord. (km)	Time zone
!	US1	='SLC'	24127	419.836	4514.922	7	!
!	US2	='BOI'	24131	84.142	4811.368	7	!
!	US3	='RTV'	24061	721.565	4768.848	7	!

---

1  
Four character string for station name  
(MUST START IN COLUMN 9)

2  
Five digit integer for station ID

!END!

---

INPUT GROUP: 9 -- Precipitation station parameters

---

PRECIPITATION STATION VARIABLES  
(One record per station -- 9 records in all)  
(NOT INCLUDED IF NPSTA = 0)

	1	2	Name	Station Code	X coord. (km)	Y coord. (km)
--	---	---	------	-----------------	------------------	------------------

---

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```
! PS1  ='BYI'    101303   272.384   4713.792
! PS2  ='PIH'    107211   372.129   4752.752
! PS3  ='TWF'    109990   213.696   4709.324
! PS4  ='PVU'    427061   438.993   4452.311
! PS5  ='SLC'    427598   418.436   4515.155
! PS6  ='LGU'    429997   429.366   4626.070
! PS7  ='HIF'    429998   418.321   4452.868
! PS8  ='OGD'    429999   414.755   4561.458
! PS9  ='EVW'    483100   497.404   4569.064
```

-----  
1 Four character string for station name  
(MUST START IN COLUMN 9)

2 Six digit station code composed of state  
code (first 2 digits) and station ID (last  
4 digits)

!END!



**Attachment 2**  
**Example Volume File**

PK1S50613NF.V01

'VOLEMARB'	1	1	12	2006001	00	2006365	23	'5.7'	'site 5_06'
'N 40.0'		'N 44.0'		'N 41.5'	'W 112.0'				
'PM10'									
50									
'All segments'		1.1							
2006001	0	2006001		12					
'All segments'									
383.44425		4610.71849	3079.9	1405.1	465	513	0		
2006001	13	2006001	13						
'All segments'									
383.44425		4610.71849	3079.9	1405.1	465	513	234		
2006001	14	2006001	23						
'All segments'									
383.44425		4610.71849	3079.9	1405.1	465	513	0		
2006002	0	2006002	12						
'All segments'									
383.44425		4610.71849	2164.9	1405.1	687	360	0		
2006002	13	2006002	13						
'All segments'									
383.44425		4610.71849	2164.9	1405.1	687	360	234		
2006002	14	2006002	23						
'All segments'									
383.44425		4610.71849	2164.9	1405.1	687	360	0		
2006003	0	2006003	12						
'All segments'									
383.44425		4610.71849	4970.9	1405.1	593	828	0		
2006003	13	2006003	13						
'All segments'									
383.44425		4610.71849	4970.9	1405.1	593	828	234		
2006003	14	2006003	23						
'All segments'									
383.44425		4610.71849	4970.9	1405.1	593	828	0		
2006004	0	2006004	12						
'All segments'									
383.44425		4610.71849	2116.9	1405.1	465	352	0		
2006004	13	2006004	13						
'All segments'									
383.44425		4610.71849	2116.9	1405.1	465	352	234		
2006004	14	2006004	23						
'All segments'									
383.44425		4610.71849	2116.9	1405.1	465	352	0		
2006005	0	2006005	12						
'All segments'									
383.44425		4610.71849	2582.9	1405.1	839	430	0		
2006005	13	2006005	13						
'All segments'									
383.44425		4610.71849	2582.9	1405.1	839	430	234		
2006005	14	2006005	23						
'All segments'									
383.44425		4610.71849	2582.9	1405.1	839	430	0		
2006006	0	2006006	12						
'All segments'									
383.44425		4610.71849	1610.9	1405.1	558	268	0		
2006006	13	2006006	13						
'All segments'									
383.44425		4610.71849	1610.9	1405.1	558	268	234		
2006006	14	2006006	23						
'All segments'									
383.44425		4610.71849	1610.9	1405.1	558	268	0		
2006007	0	2006007	12						
'All segments'									
383.44425		4610.71849	3255.9	1405.1	687	542	0		
2006007	13	2006007	13						

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'All segments'							
	383.44425	4610.71849	3255.9	1405.1	687	542	234
2006007	14 2006007	23					
'All segments'							
	383.44425	4610.71849	3255.9	1405.1	687	542	0
2006008	0 2006008	12					
'All segments'							
	383.44425	4610.71849	7460.9	1405.1	593	1243	0
2006008	13 2006008	13					
'All segments'							
	383.44425	4610.71849	7460.9	1405.1	593	1243	234
2006008	14 2006008	23					
'All segments'							
	383.44425	4610.71849	7460.9	1405.1	593	1243	0
2006009	0 2006009	12					
'All segments'							
	383.44425	4610.71849	3228.9	1405.1	688	538	0
2006009	13 2006009	13					
'All segments'							
	383.44425	4610.71849	3228.9	1405.1	688	538	234
2006009	14 2006009	23					
'All segments'							
	383.44425	4610.71849	3228.9	1405.1	688	538	0
2006010	0 2006010	12					
'All segments'							
	383.44425	4610.71849	1952.9	1405.1	687	325	0
2006010	13 2006010	13					
'All segments'							
	383.44425	4610.71849	1952.9	1405.1	687	325	234
2006010	14 2006010	23					
'All segments'							
	383.44425	4610.71849	1952.9	1405.1	687	325	0
2006011	0 2006011	12					
'All segments'							
	383.44425	4610.71849	2732.9	1405.1	687	455	0
2006011	13 2006011	13					
'All segments'							
	383.44425	4610.71849	2732.9	1405.1	687	455	234
2006011	14 2006011	23					
'All segments'							
	383.44425	4610.71849	2732.9	1405.1	687	455	0
2006012	0 2006012	12					
'All segments'							
	383.44425	4610.71849	2448.9	1405.1	520	408	0
2006012	13 2006012	13					
'All segments'							
	383.44425	4610.71849	2448.9	1405.1	520	408	234
2006012	14 2006012	23					
'All segments'							
	383.44425	4610.71849	2448.9	1405.1	520	408	0
2006013	0 2006013	12					
'All segments'							
	383.44425	4610.71849	1894.9	1405.1	593	315	0
2006013	13 2006013	13					
'All segments'							
	383.44425	4610.71849	1894.9	1405.1	593	315	234
2006013	14 2006013	23					
'All segments'							
	383.44425	4610.71849	1894.9	1405.1	593	315	0
2006014	0 2006014	12					
'All segments'							
	383.44425	4610.71849	1516.9	1405.1	773	252	0
2006014	13 2006014	13					

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'All segments'									
	383.44425								
2006014	14	2006014	23	4610.71849	1516.9	1405.1	773	252	234
'All segments'									
	383.44425								
2006015	0	2006015	12	4610.71849	1516.9	1405.1	773	252	0
'All segments'									
	383.44425								
2006015	13	2006015	13	4610.71849	2913.9	1405.1	644	485	0
'All segments'									
	383.44425								
2006015	14	2006015	23	4610.71849	2913.9	1405.1	644	485	234
'All segments'									
	383.44425								
2006016	0	2006016	12	4610.71849	2913.9	1405.1	644	485	0
'All segments'									
	383.44425								
2006016	13	2006016	13	4610.71849	2951.9	1405.1	688	491	0
'All segments'									
	383.44425								
2006016	14	2006016	23	4610.71849	2951.9	1405.1	688	491	234
'All segments'									
	383.44425								
2006017	0	2006017	12	4610.71849	2951.9	1405.1	688	491	0
'All segments'									
	383.44425								
2006017	13	2006017	13	4610.71849	2026.9	1405.1	601	337	0
'All segments'									
	383.44425								
2006017	14	2006017	23	4610.71849	2026.9	1405.1	601	337	234
'All segments'									
	383.44425								
2006018	0	2006018	12	4610.71849	2026.9	1405.1	601	337	0
'All segments'									
	383.44425								
2006018	13	2006018	13	4610.71849	2431.9	1405.1	558	405	0
'All segments'									
	383.44425								
2006018	14	2006018	23	4610.71849	2431.9	1405.1	558	405	234
'All segments'									
	383.44425								
2006019	0	2006019	12	4610.71849	2431.9	1405.1	558	405	0
'All segments'									
	383.44425								
2006019	13	2006019	13	4610.71849	7294.9	1405.1	688	1215	0
'All segments'									
	383.44425								
2006019	14	2006019	23	4610.71849	7294.9	1405.1	688	1215	234
'All segments'									
	383.44425								
2006020	0	2006020	12	4610.71849	7294.9	1405.1	688	1215	0
'All segments'									
	383.44425								
2006020	13	2006020	13	4610.71849	4728.9	1405.1	688	788	0
'All segments'									
	383.44425								
2006020	14	2006020	23	4610.71849	4728.9	1405.1	688	788	234
'All segments'									
	383.44425								
2006021	0	2006021	12	4610.71849	4728.9	1405.1	688	788	0
'All segments'									
	383.44425								
2006021	13	2006021	13	4610.71849	4929.9	1405.1	839	821	0

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'All segments'							
	383.44425						
2006021	14	2006021	23	4610.71849	4929.9	1405.1	839
'All segments'							821
	383.44425						234
2006022	0	2006022	12	4610.71849	4929.9	1405.1	839
'All segments'							821
	383.44425						0
2006022	13	2006022	13	4610.71849	5034.9	1405.1	1377
'All segments'							839
	383.44425						0
2006022	14	2006022	23	4610.71849	5034.9	1405.1	1377
'All segments'							839
	383.44425						234
2006023	0	2006023	12	4610.71849	5034.9	1405.1	1377
'All segments'							839
	383.44425						0
2006023	13	2006023	13	4610.71849	2504.9	1405.1	593
'All segments'							417
	383.44425						0
2006023	14	2006023	23	4610.71849	2504.9	1405.1	593
'All segments'							417
	383.44425						234
2006024	0	2006024	12	4610.71849	2504.9	1405.1	593
'All segments'							417
	383.44425						0
2006024	13	2006024	13	4610.71849	8642.9	1405.1	1860
'All segments'							1440
	383.44425						0
2006024	14	2006024	23	4610.71849	8642.9	1405.1	1860
'All segments'							1440
	383.44425						234
2006025	0	2006025	12	4610.71849	8642.9	1405.1	1860
'All segments'							1440
	383.44425						0
2006025	13	2006025	13	4610.71849	1414.9	1405.1	558
'All segments'							235
	383.44425						0
2006025	14	2006025	23	4610.71849	1414.9	1405.1	558
'All segments'							235
	383.44425						234
2006026	0	2006026	12	4610.71849	1414.9	1405.1	558
'All segments'							235
	383.44425						0
2006026	13	2006026	13	4610.71849	1290.9	1405.1	601
'All segments'							215
	383.44425						0
2006026	14	2006026	23	4610.71849	1290.9	1405.1	601
'All segments'							215
	383.44425						234
2006027	0	2006027	12	4610.71849	1290.9	1405.1	601
'All segments'							215
	383.44425						0
2006027	13	2006027	13	4610.71849	3683.9	1405.1	688
'All segments'							613
	383.44425						0
2006027	14	2006027	23	4610.71849	3683.9	1405.1	688
'All segments'							613
	383.44425						234
2006028	0	2006028	12	4610.71849	3683.9	1405.1	688
'All segments'							613
	383.44425						0
2006028	13	2006028	13	4610.71849	1650.9	1405.1	725
'All segments'							275
	383.44425						0

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'All segments'								
	383.44425							
2006028	14	2006028	23	4610.71849	1650.9	1405.1	725	275
'All segments'								234
	383.44425							
2006029	0	2006029	12	4610.71849	1650.9	1405.1	725	275
'All segments'								0
	383.44425							
2006029	13	2006029	13	4610.71849	1403.9	1405.1	558	233
'All segments'								0
	383.44425							
2006029	14	2006029	23	4610.71849	1403.9	1405.1	558	233
'All segments'								234
	383.44425							
2006030	0	2006030	12	4610.71849	1403.9	1405.1	558	233
'All segments'								0
	383.44425							
2006030	13	2006030	13	4610.71849	1145.9	1405.1	730	190
'All segments'								0
	383.44425							
2006030	14	2006030	23	4610.71849	1145.9	1405.1	730	190
'All segments'								234
	383.44425							
2006031	0	2006031	12	4610.71849	1145.9	1405.1	730	190
'All segments'								0
	383.44425							
2006031	13	2006031	13	4610.71849	3029.9	1405.1	593	504
'All segments'								0
	383.44425							
2006031	14	2006031	23	4610.71849	3029.9	1405.1	593	504
'All segments'								234
	383.44425							
2006032	0	2006032	12	4610.71849	3029.9	1405.1	593	504
'All segments'								0
	383.44425							
2006032	13	2006032	13	4610.71849	1794.9	1405.1	773	299
'All segments'								0
	383.44425							
2006032	14	2006032	23	4610.71849	1794.9	1405.1	773	299
'All segments'								234
	383.44425							
2006033	0	2006033	12	4610.71849	1794.9	1405.1	773	299
'All segments'								0
	383.44425							
2006033	13	2006033	13	4610.71849	1641.9	1405.1	601	273
'All segments'								0
	383.44425							
2006033	14	2006033	23	4610.71849	1641.9	1405.1	601	273
'All segments'								234
	383.44425							
2006034	0	2006034	12	4610.71849	1641.9	1405.1	601	273
'All segments'								0
	383.44425							
2006034	13	2006034	13	4610.71849	2589.9	1405.1	465	431
'All segments'								0
	383.44425							
2006034	14	2006034	23	4610.71849	2589.9	1405.1	465	431
'All segments'								234
	383.44425							
2006035	0	2006035	12	4610.71849	2589.9	1405.1	465	431
'All segments'								0
	383.44425							
2006035	13	2006035	13	4610.71849	950.9	1405.1	725	158
'All segments'								0



**Attachment 3**

**CALPUFF Model-Predicted PM<sub>2.5</sub> Concentrations and Contribution to Actual UDAQ  
Monitored Values from 98,000 lb. Rocket Motor**

**Model Predicted Contribution from ATK 98,000 lb. Rocket Motor to UDAQ sites on "Red Burn" Days**

The "All Receptors" column represents maximum predicted concentrations at all receptors in the model (i.e. county borders and UDAQ monitors).

Year	Date	Red Burn Days			All Receptors			Brigham City			Harrisville			Cottonwood			Hawthorne			North Salt Lake			Rose Park								
		SL	UTAH	WEBER	Model	UDAQ	% of Model	(ug/m3)	Model	UDAQ	% of Model	(ug/m3)	Model	UDAQ	% of Model	(ug/m3)	Model	UDAQ	% of Model	(ug/m3)	Model	UDAQ	% of Model	(ug/m3)	Model	UDAQ	% of Model	(ug/m3)			
2006	Jan 26	X			0	0	40%	0	42.8	0%	0	47.6	0%	0	43.4	0%	0	40.3	0%	0	43.3	0%	0	43.3	0%	0	43.3	0%			
	Dec 6	X			0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	48.6	0%	0	48.6	0%	0	48.6	0%	0	48.6	0%			
	Dec 7	X			2.26E-07	0	24.7	0%	0	24.6	0%	0	30.1	0%	0	34.2	0%	0	41.4	0%	0	44.3	0%	0	44.3	0%	0	44.3	0%		
	Dec 8	X			0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	44.3	0%	0	44.3	0%	0	44.3	0%	0	44.3	0%			
	Dec 21	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	37.7	0%	0	37.7	0%	0	37.7	0%	0	37.7	0%			
	Dec 22	X	X		0	0	41.8	0%	0	41.5	0%	0	0	0%	0	0	0%	0	39.3	0%	0	39.3	0%	0	39.3	0%	0	39.3	0%		
	Dec 23	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	23.2	0%	0	23.2	0%	0	23.2	0%	0	23.2	0%			
	Dec 24	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	27.5	0%	0	27.5	0%	0	27.5	0%	0	27.5	0%			
	Dec 25	X	X		0	0	21.5	0%	0	19.1	0%	0	16.1	0%	0	17.2	0%	0	23.5	0%	0	29	0%	0	29	0%	0	29	0%		
	Dec 31	X	X		0	0	23.9	0%	0	24.9	0%	0	25.3	0%	0	27.9	0%	0	29.2	0%	0	29.2	0%	0	29.2	0%	0	29.2	0%		
2007	Jan 1	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	27.9	0%	0	27.9	0%	0	27.9	0%	0	27.9	0%			
	Jan 2	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	36.3	0%	0	36.3	0%	0	36.3	0%	0	36.3	0%			
	Jan 3	X	X		0	0	30.8	0%	0	31.6	0%	0	35	0%	0	31.4	0%	0	36.6	0%	0	36	0%	0	34.3	0%	0	34.3	0%		
	Jan 16	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	44.8	0%	0	44.8	0%	0	47.7	0%	0	47.7	0%			
	Jan 17	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	48.4	0%	0	48.4	0%	0	48.4	0%	0	48.4	0%			
	Jan 18	X	X		0	0	25	0%	0	30.3	0%	0	31.8	0%	0	29.7	0%	0	42.8	0%	0	49.8	0%	0	52.2	0%	0	52.2	0%		
	Jan 19	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	47.2	0%	0	47.2	0%	0	55.7	0%	0	55.7	0%			
	Jan 20	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	65.2	0%	0	65.2	0%	0	66.6	0%	0	66.6	0%			
	Jan 21	X	X		0	0	14.2	0%	0	26.2	0%	0	27.5	0%	0	19.9	0%	0	16.3	0%	0	18	0%	0	20.5	0%	0	20.5	0%		
	Jan 22	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	27.2	0%	0	27.2	0%	0	32.5	0%	0	32.5	0%			
	Jan 23	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	46.8	0%	0	46.8	0%	0	44.1	0%	0	44.1	0%			
	Jan 24	X	X		1.09E-08	1.02E-08	33.6	0.000000%	5.86E-10	45.2	0.000000%	1.08E-09	50.4	0.000000%	1.44E-10	45.1	0.000000%	5.84E-10	51.8	0.000000%	3.14E-10	58	0.000000%	1.04E-09	58	0.000000%	1.04E-09	58	0.000000%	1.04E-09	
2008	Jan 25	X	X		1.66E-03	7.07E-04	6.75E-04	7.20E-04	0	0	0%	0	0	0%	0	3.21E-04	0	1.09E-04	64.2	0.000000%	4.99E-05	1.73E-04	62	0.0003%	6.75E-05	0	0	0	0	0	0
	Jan 26	X	X		2.11E-06	0	0	0%	0	0	0%	0	0	0%	0	1.55E-08	0	4.95E-09	75.5	0.000000%	1.40E-09	3.98E-09	79.2	0.000000%	0	0	0	0	0	0	
	Jan 27	X	X		0	0	55.3	0%	0	56.8	0%	0	62.3	0%	0	65.5	0%	0	86.7	0%	0	85	0%	0	78.7	0%	0	81.1	0%		
	Jan 28	X	X		1.96E-07	0	0	0%	0	0	0%	0	0	0%	0	6.64E-10	0	7.6E-10	76	0.000000%	6.30E-10	1.59E-08	81.1	0.000000%	1.52E-08	0	0	0	0	0	0
	Jan 29	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	64.6	0%	0	64.6	0%	0	80.6	0%	0	80.6	0%	0	80.6	0%
	Jan 30	X	X		0	0	64.6	0%	0	72.4	0%	0	68.4	0%	0	78.1	0%	0	71.5	0%	0	71.5	0%	0	71.5	0%	0	71.5	0%		
	Jan 31	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	33.8	0%	0	33.8	0%	0	36.6	0%	0	36.6	0%	0	36.6	0%
	Feb 6	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	31.1	0%	0	31.1	0%	0	35.4	0%	0	35.4	0%	0	35.4	0%
	Feb 7	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	37.6	0%	0	37.6	0%	0	52.9	0%	0	52.9	0%	0	52.9	0%
	Feb 5	X	X		0	0	27.5	0%	0	24.2	0%	0	26.1	0%	0	34.3	0%	0	35.1	0%	0	36.7	0%	0	38.5	0%	0	38.5	0%		
	Dec 6	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	32.5	0%	0	32.5	0%	0	35.7	0%	0	35.7	0%	0	35.7	0%
	Jan 3	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	44.4	0%	0	44.4	0%	0	46.8	0%	0	46.8	0%	0	46.8	0%
	Jan 24	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	63.8	0%	0	63.8	0%	0	59.6	0%	0	59.6	0%	0	59.6	0%
	Jan 25	X	X		0	0	43.3	0%	0	38.9	0%	0	46.8	0%	0	52.5	0%	0	54.1	0%	0	43	0%	0	43	0%	0	43	0%		
	Feb 17	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	31.3	0%	0	36.8	0%	0	32	0%	0	32	0%	0	32	0%
	Feb 18	X	X		0	0	23.2	0%	0	22.8	0%	0	21.5	0%	0	21.5	0%	0	26.7	0%	0	26.7	0%	0	36.3	0%	0	36.3	0%		
	Feb 19	X	X		1.84E-07	0	0	0%	0	0	0%	0	0	0%	0	29.3	0%	0	37.5	0%	0	36.5	0%	0	42.6	0%	0	42.6	0%		
	Feb 20	X	X		3.00E-05	3.10E-07	8.41E-08	0	0	0%	0	0	0%	0	0	0%	0	44.4	0%	0	47.4	0%	0	49.8	0%	0	49.8	0%			
	Feb 21	X	X		3.78E-04	3.26E-05	43.8	0.00001%	2.09E-05	44.5	0.00000%	1.58E-05	46.6	0.00000%	4.29E-06	49.6	0.00000%	1.81E-06	42.4	0.00000%	2.96E-06	2.18E-06	54.6	0.00000%	54.6	0.00000%	54.6	0.00000%			
	Feb 22	X	X		3.99E-05	2.65E-06	1.19E-06	0	0	0%	0	0	0%	0	0	0%	0	29.7	0.00000%	0	15.4	0%	0	18	0%	0	16.2	0%			
	Feb 28	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	28.4	0%	0	25	0%	0	27.4	0%	0	27.4	0%			



Meteorological Solutions Inc.

**Attachment 4**

**CALPUFF Model-Predicted PM<sub>2.5</sub> Concentrations and Contribution to Actual UDAQ  
Monitored Values from 45,800 lb. Rocket Motor**

**Model Predicted Contribution from ATK 45,800 lb. Rocket Motor to UDAQ sites on "Red Burn" Days**

The "All Receptors" column represents maximum model predicted concentrations at all receptors in the model (i.e. county borders and UDAQ monitors)

YEAR	DATE	Red Burn Days		All Receptors		Brigham City		Harrisville		Ogden		Bountiful		Hawthorne		Cottonwood		North Salt Lake		Rose Park			
		SL / DAVIS	UTAH	WEBER	Model (ug/m3)	UDAQ (ug/m3)	Model (ug/m3)	UDAQ (ug/m3)	Model (ug/m3)	UDAQ (ug/m3)													
2006	Jan 26	x			0	0	40	0%	47.8	0%	0	47.6	0%	0	43.4	0%	0	40.3	0%	0	43.3	0%	
	Dec 6	x			0	0	24.7	0%	24.6	0%	0	30.1	0%	0	34.2	0%	0	48.6	0%	0	55.4	0%	
	Dec 7	x			0	0					0		0		0		0	41.4	0%	0	44.3	0%	
	Dec 8	x			0	0					0		0		0		0	44.3	0%	0	23.8	0%	
	Dec 21	x	x		0	0					0		0		0		0	37.7	0%	0	39.9	0%	
	Dec 22	x	x		0	0	41.8	0%			0	14.8	0%	0		0		39.3	0%	0	36.8	0%	
	Dec 23	x	x		0	0					0		0		0		0	23.2	0%	0	25.8	0%	
	Dec 24	x	x		0	0					0		0		0		0	27.5	0%	0	26.3	0%	
	Dec 25	x	x		0	0	21.5	0%	19.1	0%	0	16.1	0%	0	17.2	0%	0	23.5	0%	0	21	0%	
	Dec 31				0	0	23.9	0%	24.9	0%	0	25.3	0%	0	27.9	0%	0	29.2	0%	0	30.1	0%	
2007	Jan 1	x	x	x	0	0					0		0		0		0	27.9	0%	0	26.7	0%	
	Jan 2	x	x	x	0	0					0		0		0		0	36.3	0%	0	35.2	0%	
	Jan 3	x	x	x	0	0	30.8	0%	31.6	0%	0	35	0%	0	31.4	0%	0	36	0%	0	34.3	0%	
	Jan 16	x	x	x	0	0					0		0		0		0	44.8	0%	0	47.7	0%	
	Jan 17	x	x	x	0	0					0		0		0		0	48.4	0%	0	49.3	0%	
	Jan 18	x	x	x	5.76E-11	0	25	0%	30.3	0%	0	31.8	0%	0	29.7	0%	0	42.8	0%	0	52.2	0%	
	Jan 19	x	x	x	0	0					0		0		0		0	47.2	0%	0	55.7	0%	
	Jan 20	x	x	x	0	0					0		0		0		0	65.2	0%	0	66.6	0%	
	Jan 21	x	x	x	0	0	14.2	0%	26.2	0%	0	27.5	0%	0	19.9	0%	0	16.3	0%	0	20.5	0%	
	Jan 22	x	x	x	0	0					0		0		0		0	27.2	0%	0	32.5	0%	
2008	Jan 23	x	x	x	0	0					0		0		0		0	46.8	0%	0	44.1	0%	
	Jan 24	x	x	x	1.64E-08	6.75E-11	33.6	0.0000%	3.78E-10	45.2	0.0000%	6.598E-10	50.4	0.0000%	1.03E-09	45.1	0.0000%	4.33E-10	51.8	0.0000%	7.52E-10	3.86E-10	
	Jan 25	x	x	x	6.72E-04	5.52E-04			5.61E-04		2.46E-04		8.94E-05		64.2	0.0001%	6.37E-05		1.36E-04		62.0	0.0002%	
	Jan 26	x	x	x	3.12E-06	0				0	1.02E-08		7.55	0.0000%	9.42E-10		2.56E-09		79.2	0.0000%	0		
	Jan 27	x	x	x	0	0	55.3	0%	0	56.8	0%	0	62.3	0%	0	65.5	0%	0	86.7	0%	0	85	0%
	Jan 28	x	x	x	1.11E-07	0				0		0		0		0	3.85E-10		76.0	0.0000%	3.72E-10	9.08E-10	
	Jan 29	x	x	x	0	0					0		0		0		0	64.6	0%	0	80.6	0%	
	Jan 30	x	x	x	0	0	64.6	0%	0	72.4	0%	0	76.9	0%	0	68.4	0%	0	78.1	0%	0	71.5	0%
	Jan 31	x	x	x	0	0					0		0		0		0	33.8	0%	0	36.6	0%	
	Feb 6	x	x	x	0	0					0		0		0		0	31.1	0%	0	35.4	0%	
2008	Feb 7	x	x	x	0	0					0		0		0		0	37.6	0%	0	52.9	0%	
	Dec 5	x	x	x	0	0	27.5	0%	24.2	0%	0	26.1	0%	0	34.3	0%	0	35.1	0%	0	36.7	0%	
	Dec 6	x	x	x	0	0					0		0		0		0	32.5	0%	0	35.7	0%	
	Jan 3	x	x	x	0	0					0		0		0		0	44.4	0%	0	46.8	0%	
	Jan 24	x	x	x	0	0					0		0		0		0	63.8	0%	0	59.6	0%	
	Jan 25	x	x	x	0	0	43.3	0%	0	38.9	0%	0	46.8	0%	0	52.5	0%	0	54.1	0%	0	43	0%
	Feb 17	x	x	x	0	0					0		0		0		0	36.5	0%	0	32	0%	
	Feb 18	x	x	x	0	0	23.2	0%	0	22.8	0%	0	20	0%	0	21.5	0%	0	26.7	0%	0	36.3	0%
	Feb 19	x	x	x	1.25E-06	0				0		0		0		0	28.6	0%	0	36.5	0%		
	Feb 20	x	x	x	1.27E-04	2.90E-09			3.05E-11		3.73	0%	0		0		0	37.5	0%	0	42.6	0%	
2008	Feb 21	x	x	x	1.34E-04	4.38E-07	43.8	0.0000%	1.29E-07	44.5	0.0000%	7.53E-08	46.6	0.0000%	9.96E-09	49.6	0.0000%	1.85E-09	47.4	0%	0	44.4	0%
	Feb 22	x	x	x	0	0					0		0		0		0	42.4	0.0000%	4.02E-10	43.6	0.0000%	
	Feb 22	x	x	x	0	0					0		0		0		0	15.4	0%	0	18	0%	
	Feb 28	x	x	x	0	0					0		0		0		0	28.4	0%	0	25	0%	
2008	Feb 28	x	x	x	0	0					0		0		0		0	27.4	0%	0	0	29	0%



**Attachment 5**

**CALPUFF Model-Predicted PM<sub>2.5</sub> Concentrations and Contribution to Actual UDAQ  
Monitored Values from 25,942 lb. Rocket Motor**

**Model Predicted Contribution from ATK 25,942 lb. Rocket Motor to UDAQ sites on "Red Burn" Days**

The "All Receptors" column represents maximum model predicted concentrations at all receptors in the model (i.e. county borders and UDAQ monitors)

YEAR	DATE	Red Burn Days			All Receptors			Brigham City			Harrisville			Odgen			Bountiful			Hawthorne			Cottonwood			North Salt Lake			Rose Park										
		SL / DAVIS	UTAH	WEBER	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ	Model (ug/m3)	UDAQ (ug/m3)	% of UDAQ								
2006	Jan 26	X			0	40	0%	0	42.8	0%	0	47.6	0%	0	43.4	0%	0	40.3	0%	0	43.3	0%	0	40.3	0%	0	43.3	0%	0	40.3	0%	0							
	Dec 6	X			0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Dec 7	X			9.39E-08	0	24.7	0%	0	24.6	0%	0	30.1	0%	0	34.2	0%	0	41.4	0%	0	44.3	0%	0	37.7	0%	0	39.3	0%	0									
	Dec 8	X			0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Dec 21	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Dec 22	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Dec 23	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Dec 24	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Dec 25	X	X		0	21.5	0%	0	19.1	0%	0	16.1	0%	0	17.2	0%	0	23.5	0%	0	29	0%	0	29	0%	0	29	0%	0	29	0%	0							
	Dec 31	X			0	23.9	0%	0	24.9	0%	0	25.3	0%	0	27.9	0%	0	29.2	0%	0	30.1	0%	0	30.1	0%	0	30.1	0%	0	30.1	0%	0							
2007	Jan 1	X	X		0	1.80E-08	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Jan 2	X	X		0	30.8	0%	0	31.6	0%	0	35	0%	0	31.4	0%	0	36.6	0%	0	36	0%	0	34.3	0%	0	35.2	0%	0	34.3	0%	0							
	Jan 3	X	X		0	5.61E-06	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Jan 16	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Jan 17	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Jan 18	X	X		1.93E-10	0	25	0%	0	30.3	0%	0	31.8	0%	0	29.7	0%	0	42.8	0%	0	49.8	0%	0	52.2	0%	0	55.7	0%	0	66.6	0%	0						
	Jan 19	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Jan 20	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
	Jan 21	X	X		0	14.2	0%	0	26.2	0%	0	27.5	0%	0	19.9	0%	0	16.3	0%	0	18	0%	0	20.5	0%	0	32.5	0%	0	32.5	0%	0							
	Jan 22	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0							
2008	Jan 23	X	X		4.32E-11	0	33.6	0.000%	2.76E-10	45.2	0.000%	5.09E-10	50.4	0.000%	8.44E-10	45.1	0.000%	3.66E-10	51.8	0.000%	2.12E-10	58	0.000%	6.15E-10	44.1	0%	0	52.2	0%	0	55.7	0%	0	66.6	0%	0			
	Jan 24	X	X		5.04E-08	0	3.00E-04	3.00E-04	2.85E-04	1.33E-04	0	4.79E-05	64.2	0.0001%	2.33E-05	7.25E-05	62	0.0001%	5.91E-05	7.25E-05	62	0.0001%	5.91E-05	62	0.0001%	5.91E-05	62	0.0001%	5.91E-05	62	0.0001%	5.91E-05	62	0.0001%	5.91E-05				
	Jan 26	X	X		0	3.20E-06	0	0	0	0	0%	0	0	0	8.85E-09	0	0	1.06E-07	75.5	0.000%	2.13E-07	3.40E-08	79.2	0.000%	6.38E-08	0	0	0	0	0	0	0	0	0	0				
	Jan 27	X	X		0	55.3	0%	0	56.8	0%	0	62.3	0%	0	65.5	0%	0	86.7	0%	0	85	0%	0	78.7	0%	0	81.1	0.000%	5.73E-09	81.1	0.000%	5.73E-09	81.1	0.000%	5.73E-09				
	Jan 28	X	X		0	7.28E-08	0	0	0	0	0%	0	0	0	2.57E-10	0	0	2.57E-10	76	0.000%	2.53E-10	5.98E-10	81.1	0.000%	5.73E-09	0	0	0	0	0	0	0	0	0	0				
	Jan 29	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Jan 30	X	X		0	64.6	0%	0	72.4	0%	0	76.9	0%	0	68.4	0%	0	78.1	0%	0	71.5	0%	0	80.6	0%	0	80.6	0%	0	80.6	0%	0	80.6	0%	0				
	Jan 31	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Feb 6	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Feb 7	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
2008	Dec 5	X			0	27.5	0%	0	24.2	0%	0	26.1	0%	0	34.3	0%	0	35.1	0%	0	36.7	0%	0	38.5	0%	0	35.7	0%	0	46.8	0%	0	46.8	0%	0				
	Dec 6	X			0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Jan 3	X			0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Jan 24	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Jan 25	X	X		0	43.3	0%	0	38.9	0%	0	46.8	0%	0	52.5	0%	0	54.1	0%	0	43	0%	0	43	0%	0	43	0%	0	43	0%	0	43	0%	0				
	Feb 17	X	X		0	20.7E-04	0	0	0	0	0%	0	0	0	3.99E-08	0	0	2.44E-06	31.3	0.000%	6.31E-06	36.8	0.000%	3.88E-07	44.1E-07	32	0.000%	38.5	0%	0	38.5	0%	0	38.5	0%	0	38.5	0%	0
	Feb 18	X	X		0	23.2	0%	0	22.8	0%	0	20	0%	0	21.5	0%	0	26.7	0%	0	23.2	0%	0	36.3	0%	0	35.7	0%	0	42.6	0%	0	42.6	0%	0				
	Feb 19	X	X		0	3.97E-05	0	0	0	0	0%	0	0	0	29.3	0%	0	35.7	0%	0	44.4	0%	0	47.4	0%	0	49.8	0%	0	54.6	0.000%	0	54.6	0.000%	0				
	Feb 20	X	X		0	3.98E-03	0	0	0	0	0%	0	0	0	45.5	0.0015%	5.68E-05	0	0	42.4	0.000%	0	43.6	0%	0	43.6	0%	0	43.6	0%	0	43.6	0%	0					
	Feb 21	X	X		0	5.95E-03	0	0	0	0	0%	0	0	0	44.5	0.00060%	4.31E-06	0	0	49.6	0.0001%	0	43.1	0%	0	43.1	0%	0	43.1	0%	0	43.1	0%	0					
2008	Feb 22	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Feb 23	X	X		0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	0				
	Feb 24	X</																																					



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**Attachment 6**

**CALPUFF Model-Predicted PM<sub>2.5</sub> Concentrations and Contribution to Actual UDAQ  
Monitored Values from 15,590 lb. Rocket Motor**

## **Model Predicted Contribution from ATK 15,590 lb. Rocket Motor to UDAQ sites on "Red Burn" Days**

The "All Receptors" column represents maximum model predicted concentrations at all receptors in the model (i.e. county borders and UDAQ monitors).



**Attachment 7**

**CALPUFF Model-Predicted PM<sub>2.5</sub> Concentrations and Contribution to Actual UDAQ  
Monitored Values from 7,295 lb. Rocket Motor**

**Model Predicted ATK 7,295 lb. Rocket Motor Contribution to UDAQ sites on "Red Burn" Days**

The "All Receptors" column represents maximum model predicted concentrations at all receptors in the model (i.e. county borders and UDAQ monitors)